either type gland. Comparative measurements of the glands using available photos of the three species[2,3] indicate the diameters of stalked and sessile glands of P. macrophylla are equal to the diameters of the individual cells of these glands in P. vulgaris and P. grandiflora. Possibly both stalked and sessile glands of P. macrophylla are unicellular, unless the greater tissue hardening achieved prevented delineation of cellular margins.

The readily demonstrated elongated stalks and the ridge-bordered sessile glands are helpful microscopic identification characteristics for differentiating the other two species from P. macrophylla, a species not previously examined with the SEM.

Literature Cited.

1. Heslop-Harrison, Y. "Scanning Electron Microscopy of Fresh Leaves of Pinguicula" Science 167: 172-174. 1970.
2. Lloyd, F. The Carnivorous Plants. Chronica Botanica, Waltham, MA 1942.
3. Panessa, B., and J. Gennaro, Jr. "Preparation of Fragile Botanical Tissues and Examination of Intracellular Contents by SEM" IITRI Proceedings, ed. O. Johari, Chicago, 1972: 326-334.

Captions.

Fig. 1: Pinguicula macrophylla, plant actual size.
Fig. 2: Close-up of leaf (x3) with drops of muscilage and trapped insect visible.
Fig. 3: 56x overview of the upper leaf surface, showing stalked glands, sessile glands, and epidermal cells.
Fig. 4: 560x close-up of the tip (gland) of a stalked gland.
Fig. 5: 560x close-up of a sessile gland.

ARE CARNIVOROUS PLANTS CARNIVOROUS?
by Stephen E. Williams

There have been debates about whether carnivorous plants use nutrients from their prey. Partly as a result of this question, scientists have performed experiments and made field observations which have demonstrated that at least some species of carnivorous plants: 1. Capture prey (1); 2. Produce digestive enzymes which digest the prey (2,3); 3. Absorb the nutrients from the digested prey (4,5,6,7); 4. Transport the absorbed nutrients to the entire plant (5,7,8,); 5. When fed will grow faster, produce more flowers, seed and otherwise prosper more than unfed control plants (9,10,11).

But is the eating of meat sufficient grounds for calling anything (animal or plant) carnivorous? In the case of animals it is not. There are omnivores which we are told eat almost anything and certain herbivores such as squirrels are known to grab an insect or two, yet we do not call them carnivores because of this. Can we then call a plant carnivorous merely because it happens to digest an insect occasionally?

To fully answer this last question it is worthwhile going over a bit of information about nutrition. When we eat we gain three things: 1. Minerals - the elements that make up the various chemicals from which our bodies are made. 2. Essential organic compounds -such as certain vitamins and amino acids (digested proteins) which our body cannot make. 3. Energy- to power our movements and the synthetic processes that repair and build our body.

How do most plants get these three kinds of nutrients? They are autotrophic. That is, they take most of their minerals up through their roots, manufacture all their organic compounds themselves and trap the energy of sunlight by making carbon dioxide into sugar.

How do carnivorous plants get these kinds of nutrients? This is a more complex question. Drosera, Pinguicula and Utricularia plants have been grown in sterile conditions without feeding (11,12,13). Both Drosophyllum and Drosera have been directly demonstrated to be photosynthetic (14). Utricularia will not flower unless it is fed (12) but Pinguicula and Drosera will carry out all their normal functions in sterile culture on inorganic media (11,13). Drosera and Pinguicula which are grown on inorganic nutrients in sterile culture from seed to seed undoubtedly take their nutrition in the same way that most other plants do. But very few carnivorous plants grow inside sterile bottles and none do without the help of a dedicated human slave (usually a graduate student). Most carnivorous plants derive nutrition from both the animals they capture and the more typical plant nutritional modes. The question then becomes "How much nutrition comes from each source?" and the answer is "No one knows."

It seems likely--although it is unproven--that the vast majority of the energy and essential organic compounds of most carnivorous plants come from photosynthesis and other synthetic processes within the plant. It seems likely--and is equally unproven--that in nature the majority of the minerals used by the plant come from the captured prey. Nearly all carnivorous plants grow in mineral-poor habitats(1) and it would certainly be of value for them to capture a mineral source.

If the conjectures above are correct, should we call carnivorous plants carnivorous? Certainly all animals to which the term applies gain almost all of their energy from the prey they capture and this would constitute an important difference between carnivorous plants and carnivorous animals.

Oddly enough, there are animal systems which seem parallel in their feeding habits to the carnivorous plants. Coral polyps with algae growing inside them grow in very mineral-poor waters with very little food to eat. It has been shown that the "carnivorous" behavior of the polyp captures an important source of minerals for itself and the algae but that the energy supply of both the polyp and algae is nearly all from the photosynthesis of the algae growing in and alongside the polyp (15). Is the polyp carnivorous? The ecologists who made this study decided it was both a carnivore and a herbivore (although it did not ingest the algae!). Perhaps we should consider carnivorous plants both carnivorous and autotrophic and avoid burdensome troubles such as having to change the name of this newsletter.

(Ed. note--We could engage in the German language habit of building impossible compound words and retitle CARNIVOROAUTOTROPHIC PLANT NEWSLETTER; or how about AUTOTROPHOCARNIVOROPHYTE NEWSLETTER? By the time a potentially interested subscriber would have decoded and analyzed it, he would have missed a year's subscription! And if you do not send in your renewal today, you may miss how all this turns out.)

REFERENCES

1. Lloyd, F.E., Carnivorous Plants. New York: Ronald Press. 1942.
2. Whitaker, E.H., Physiological studies of two species of Drosera. L. Doct. dissert., Cornell Univ., Ithaca, N.Y. 1949.
3. Hepburn, J.S. and Jones, F.M.: Proc. Am. Philos. Soc. 57, 112-129. 1918.
4. Arisz, W.H.: Nature 170, 932-933. 1952.
5. Fabian-Galan, G. and Salageanu, N.: Rev. Rom. Biol. Ser. Bot. 13, 275-280. 1968.
6. Ashley, T. and Genaro, J.F., Jr.: Natural History 80, Dec. pp. 80-85, p. 102. 1971.
7. Plummer, G.L. and Kethley, J.B.: Bot. Gaz. 125, 245-260. 1964.
8. Lüttge, U.: Die Naturwissenschaften 50, 22. 1963.
9. Darwin, F.: J. Linn. Soc. Bot. 17, 17-32. 1878.
10. Oudman, J.: Ext. Rec. Trav. Bot. Neerl. 33, 351-433. 1936.
11. Harder, R. and Zemlin, I.: Planta 73, 181-193. 1967.
12. Harder, R.: Planta 59, 459-471. 1963.
13. Harder, R.: Planta 63, 316-325. 1964.
14. Durand, R. and Zenk, M.H.: Phytochemistry 13, 1483-1492. 1974.
15. Odum, H.T. and Odum, E.P.: Ecological Monographs 25, 291-320. 1955.

BACTERIOLOGICAL AND ECOLOGICAL OBSERVATIONS OF THE NORTHERN PITCHER PLANT, SARRACENIA PURPUREA L. Summary of thesis. John Lindquist

Studies were made on the pitcher plant, Sarracenia purpurea, growing in bogs near Cambridge and Drummond, Wisconsin. The well-known habit of the plant to supplement its nutritional needs by the entrapment of insects was observed.

The pH of the pitcher fluid of field plants ranged from 3.1 to 7.2, and carbon dioxide was considered an important factor in the acidity. The microbial flora of the pitcher fluid was generally typical of plant and aquatic habitats. Proteolytic and chitinolytic bacteria were isolated and included members of the genera Pseudomonas, Chromobacterium, Serratia, Aeromonas and Cytophaga. Digestion of insects was accompanied by increases in gram-negative and proteolytic bacteria, protease and ammonia, and the digestive process appeared to be largely mediated by the bacteria. Ammonia released by microbial deamination was considered an important source of nitrogen for the plant.

Photosynthetic bacteria, generally identified as Rhodopseudomonas acidophila, were found in each of the 22 leaves tested for these bacteria. Nitrogen-fixing bacteria, identified as Klebsiella pneumoniae and Citrobacter sp. were isolated from the pitcher fluid, but no nitrogen fixation was detected in the fluid when tested by the acetylene-reduction method. Other bacteria found in the pitcher fluid include Flavobacterium, Microcyclus, Clostridium, Streptococcus, Escherichia coli and a pectin-hydrolyzing strain of Enterobacter aerogenes. Yeasts, molds, algae, protozoa and rotifers were also observed.